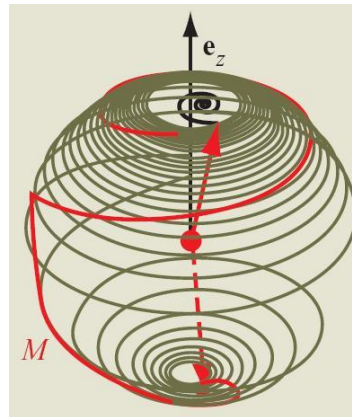
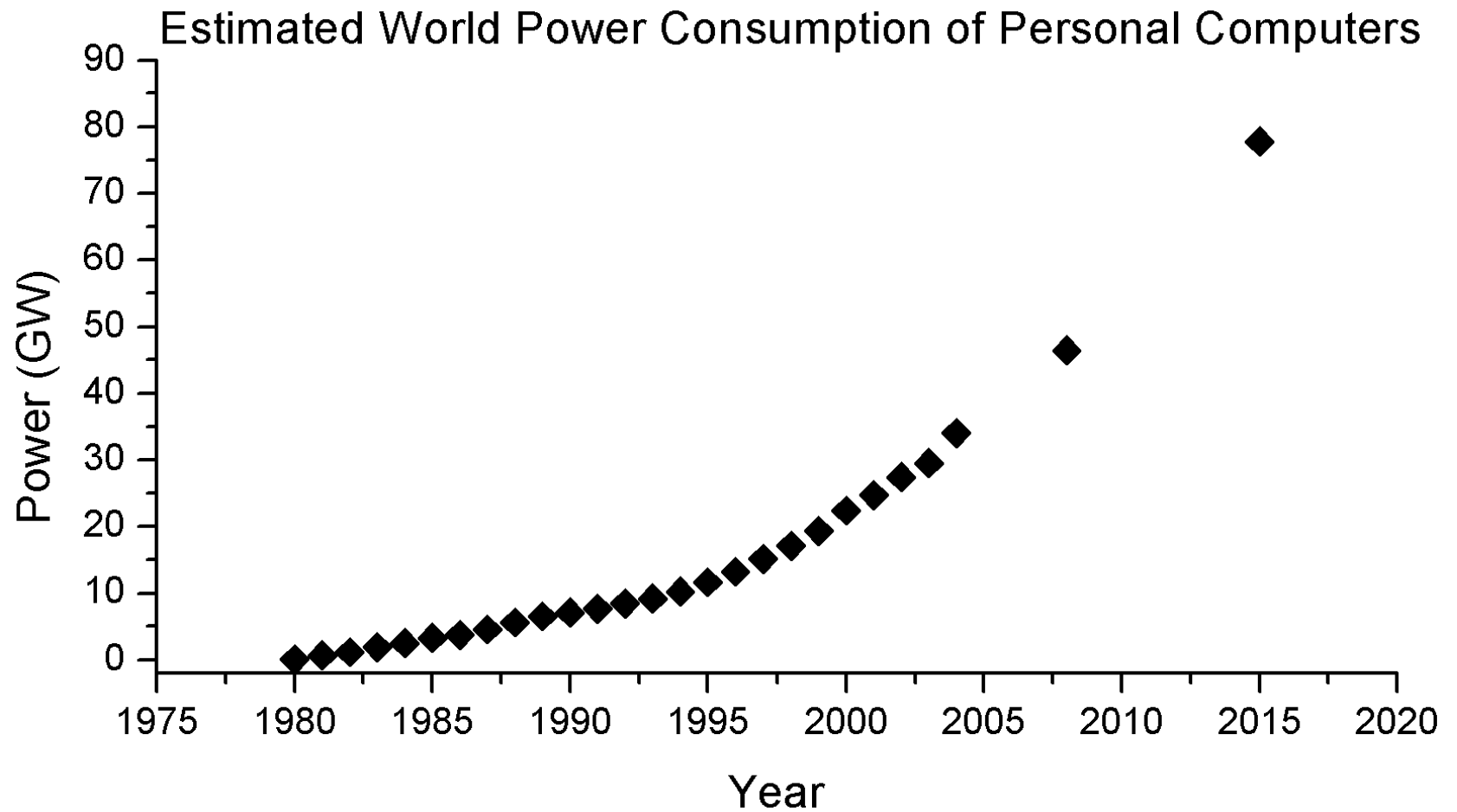


Spin-Based Digital Logic

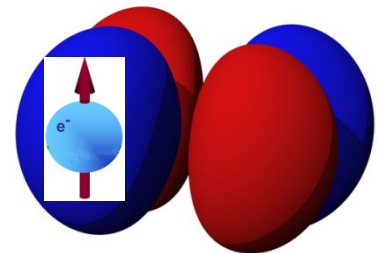
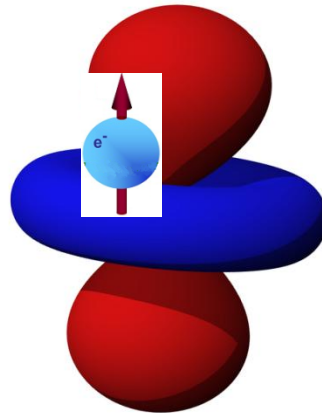
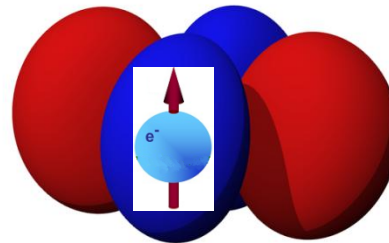
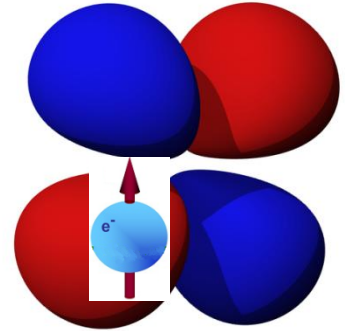
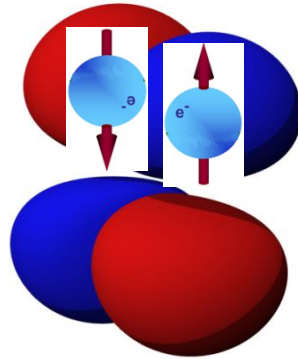
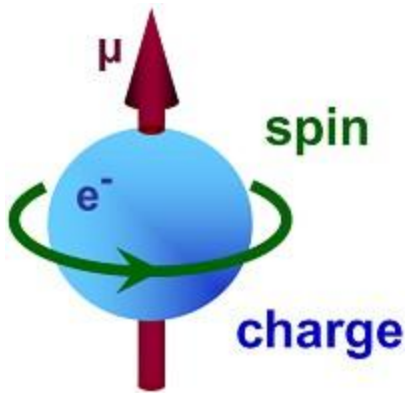
Sebastian Dietze

Physics Department, University of California at San Diego



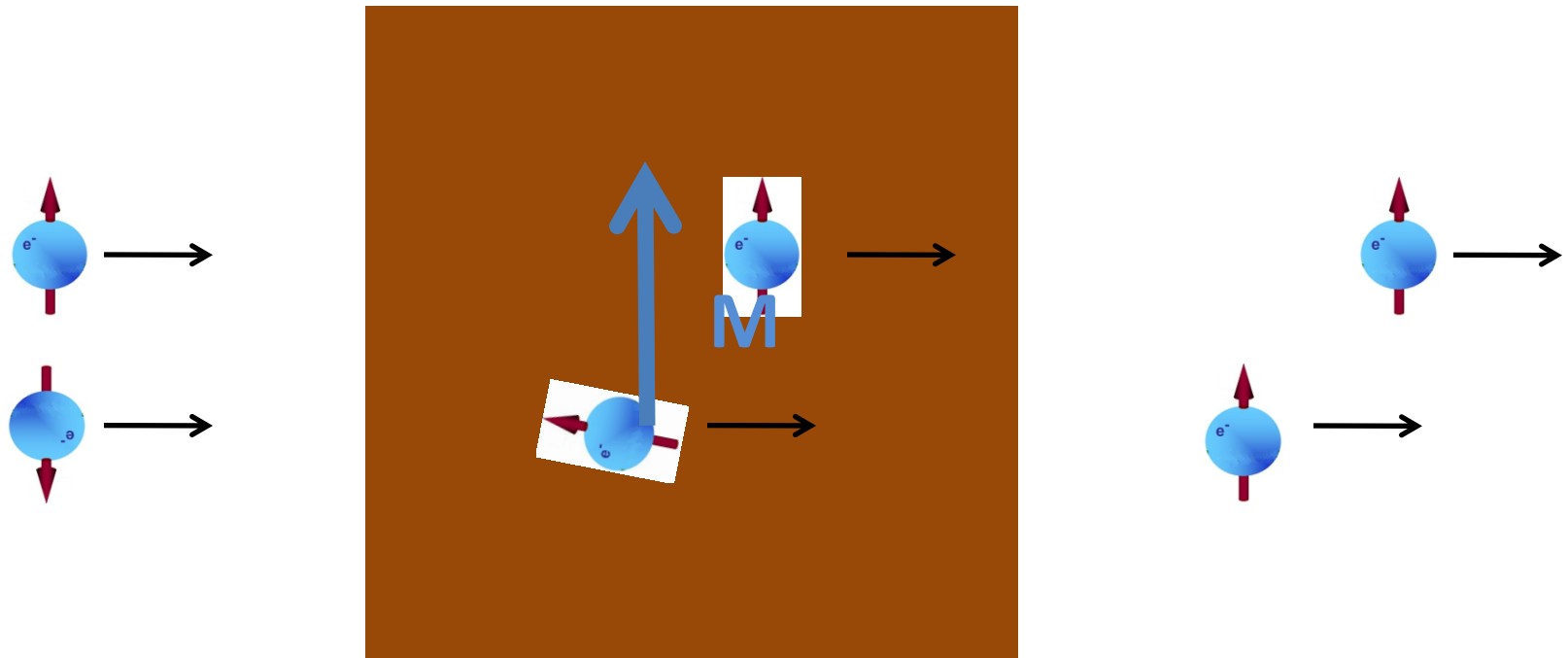


Spintronics

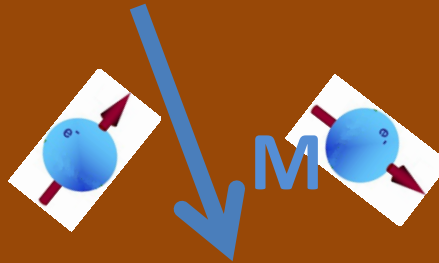
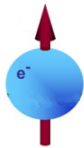


Fe
 $3d^6 4s^2$

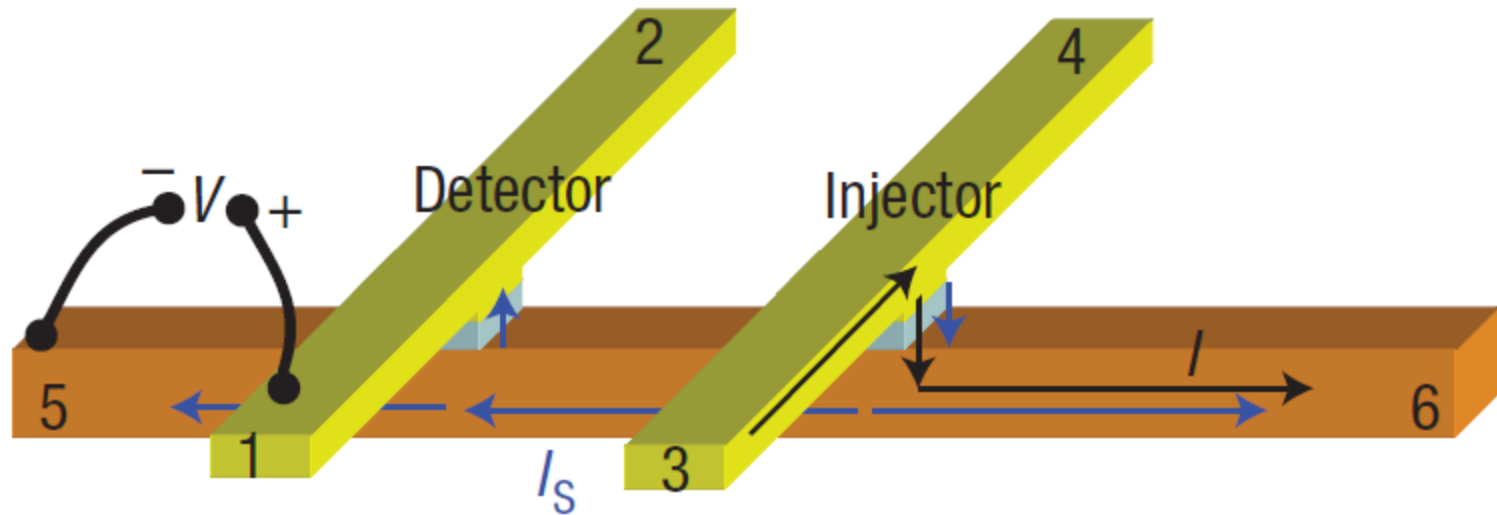
Giant Magnetoresistance



Spin-torque

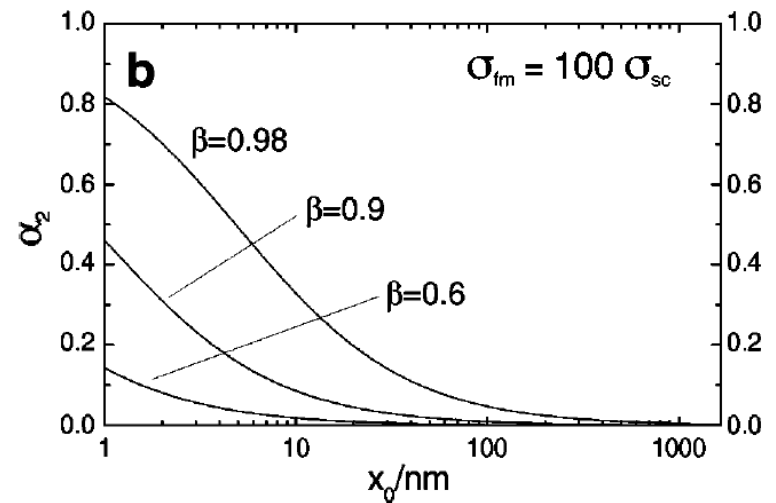
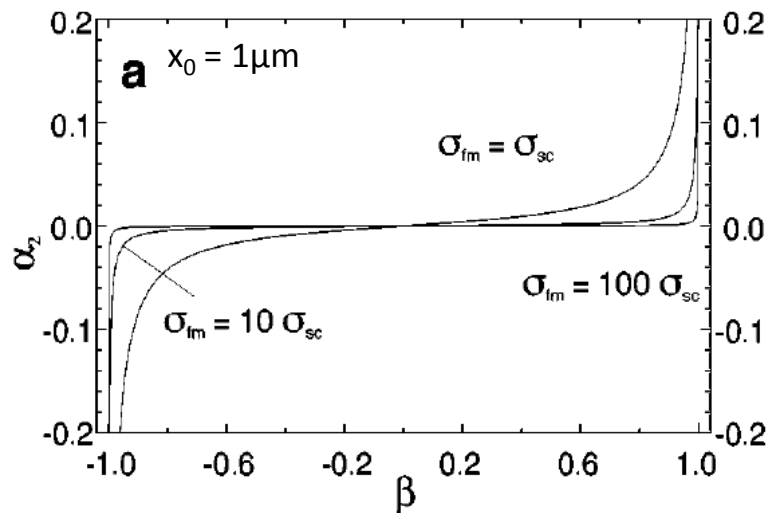
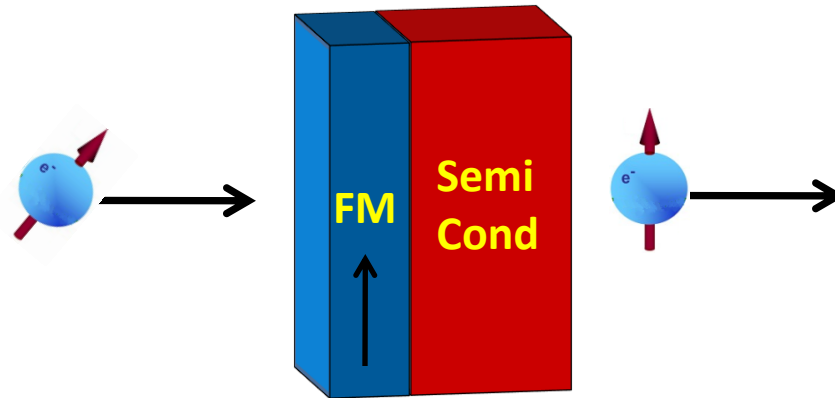


Pure Spin Current and Non-local Spin-Torque



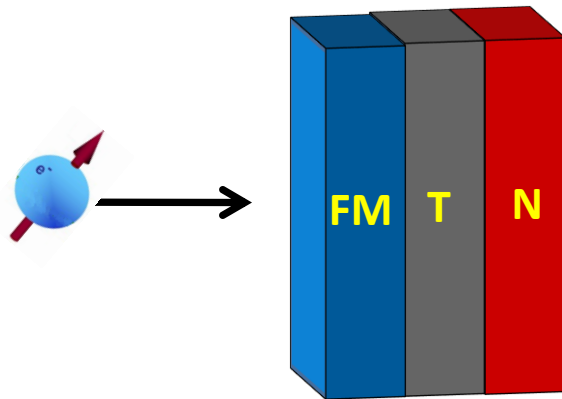
Yang, T. et al. Nature Phys. **4** 851 (2008)

Spin injection – Conductivity mismatch



Schmidt, G. et al. Phys Rev B **62** R4790 (2000)

Spin injection – Conductivity mismatch



$$\gamma = [r_F(\Delta\sigma/\sigma_F) + r_c(\Delta\Sigma/\Sigma)]/r_{FN},$$

$$r_{FN} = r_F + r_N + r_c$$

$$r_F = L_F \sigma_F / 4\sigma_{\uparrow}\sigma_{\downarrow}$$

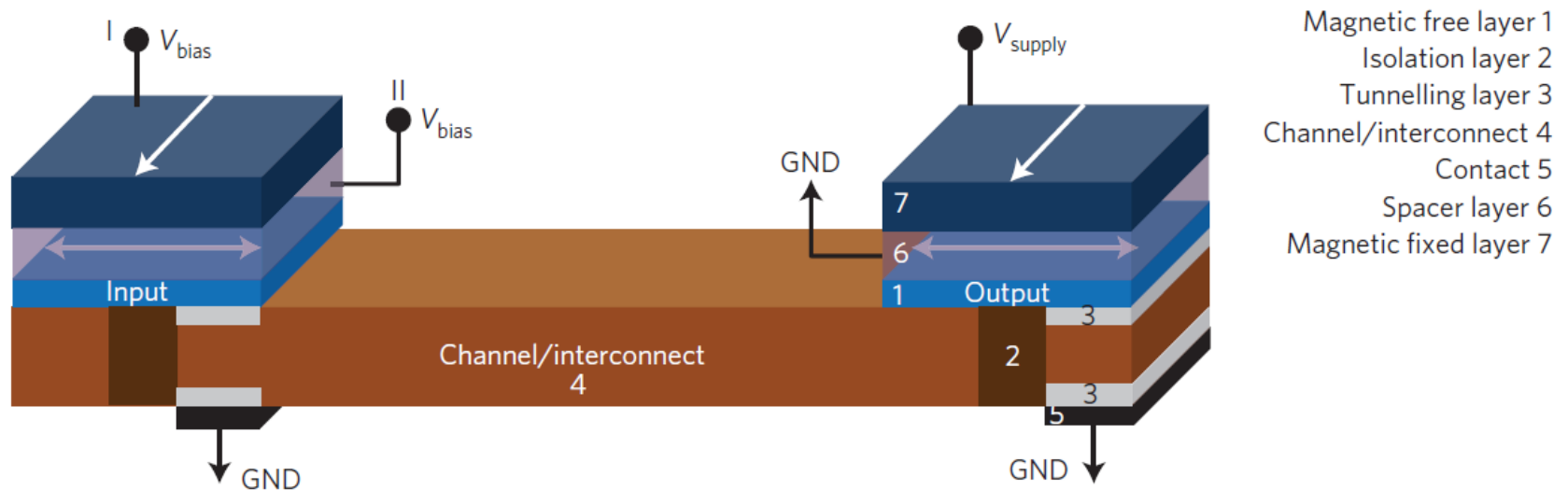
$$r_N = L_N / \sigma_N$$

$$\Delta\Sigma = \Sigma_{\uparrow} - \Sigma_{\downarrow}, \quad \Sigma = \Sigma_{\uparrow} + \Sigma_{\downarrow}$$

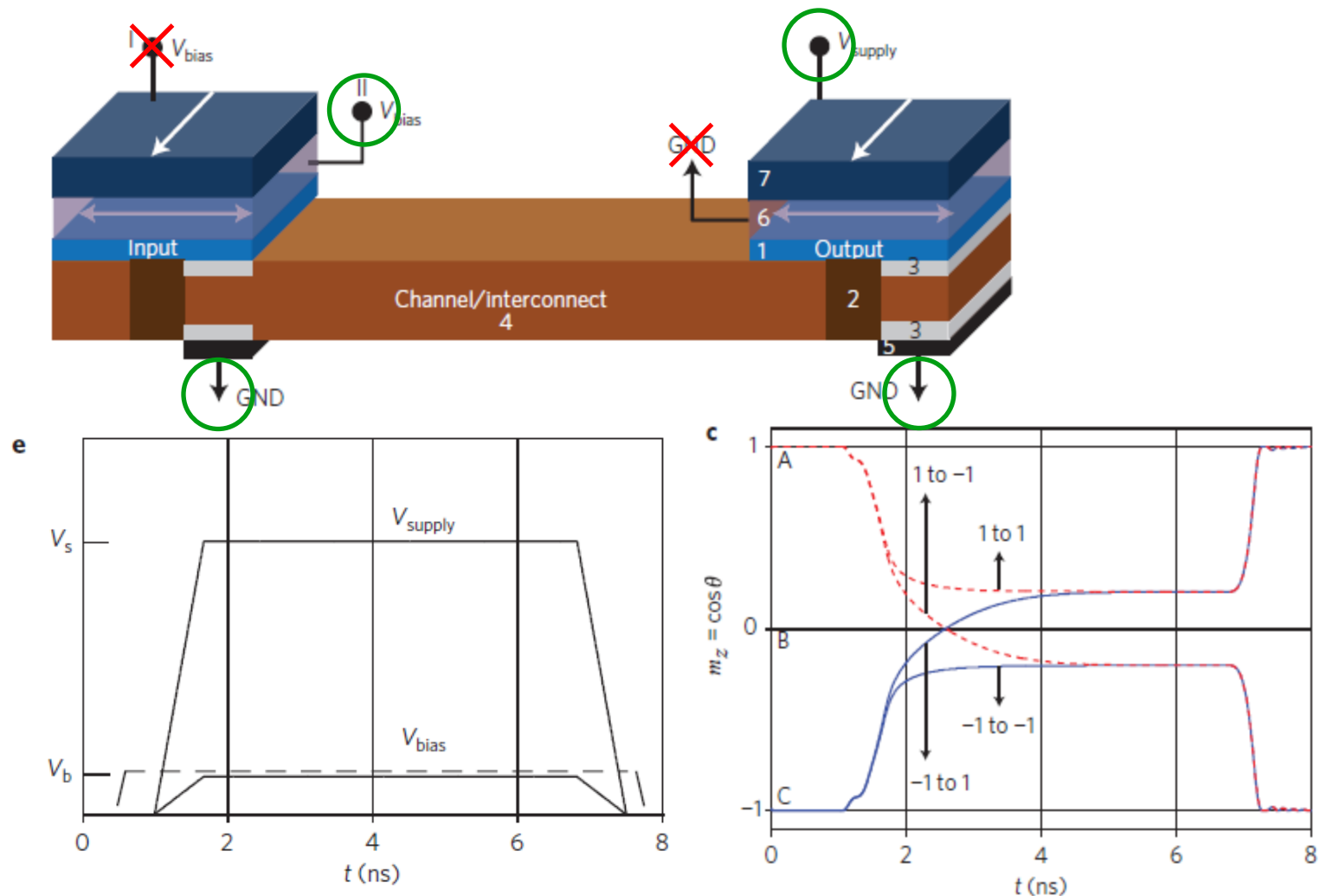
$$r_c \gtrsim L_F / \sigma_F, \quad \min\{L_N, w\} / \sigma_N$$

Rashba, E. Phys Rev B **62** R16267 (2000)

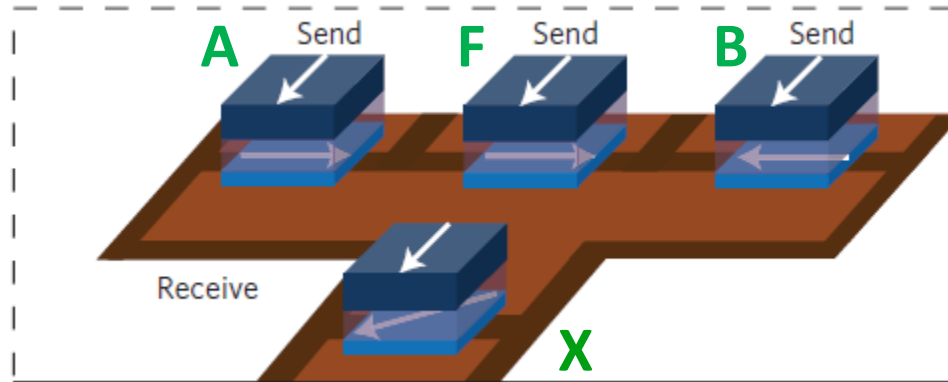
Device Structure



Buffer and NOT Gate



AND and OR Gates



$$M_F = +1, I_A = I_B = |I_F|$$

AND

$$I_F < 0$$

M_A	M_B	M_X
-1	-1	-1
-1	+1	-1
+1	-1	-1
+1	+1	+1

OR

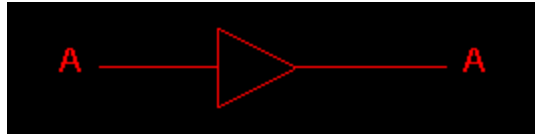
$$I_F > 0$$

M_A	M_B	M_X
-1	-1	-1
-1	+1	+1
+1	-1	+1
+1	+1	+1

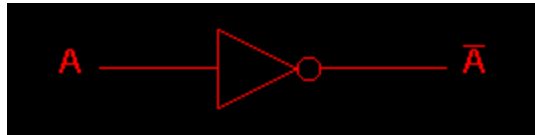
Thank you for your attention

Basic Logic Gates

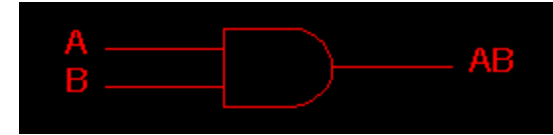
Buffer



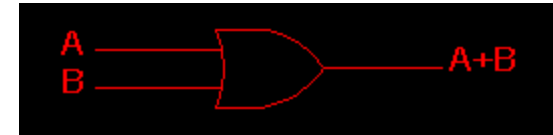
NOT



AND

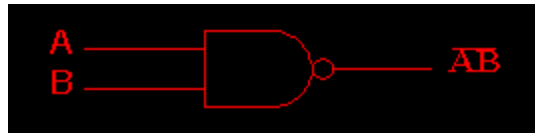


OR

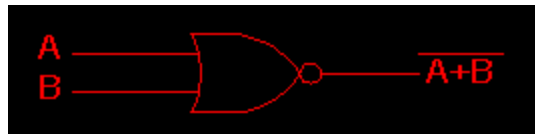


Other Logic Gates

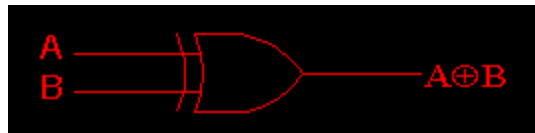
NAND



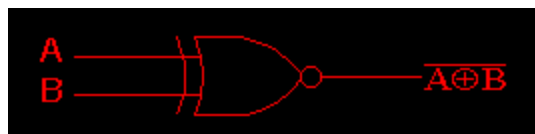
NOR



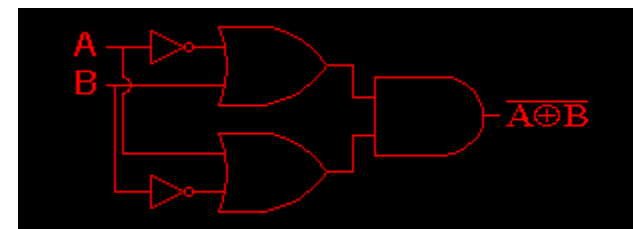
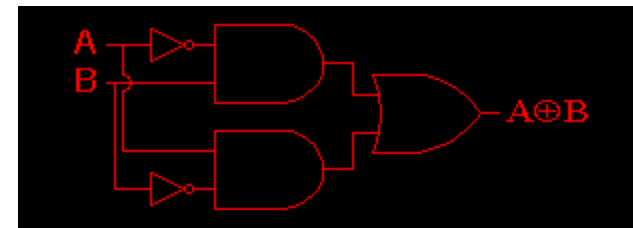
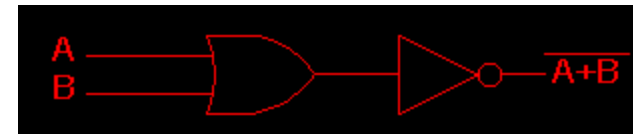
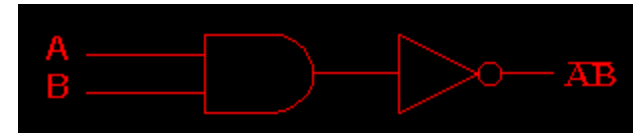
XOR



Comparator



Equivalent using Basic Gates



Spin-Valve

